PMM Science Team Meeting @ Houston

2016.10.25

Dynamical Downscaling Application for Off-line Forcing Generation for Hyper-Resolution Land Surface Modeling

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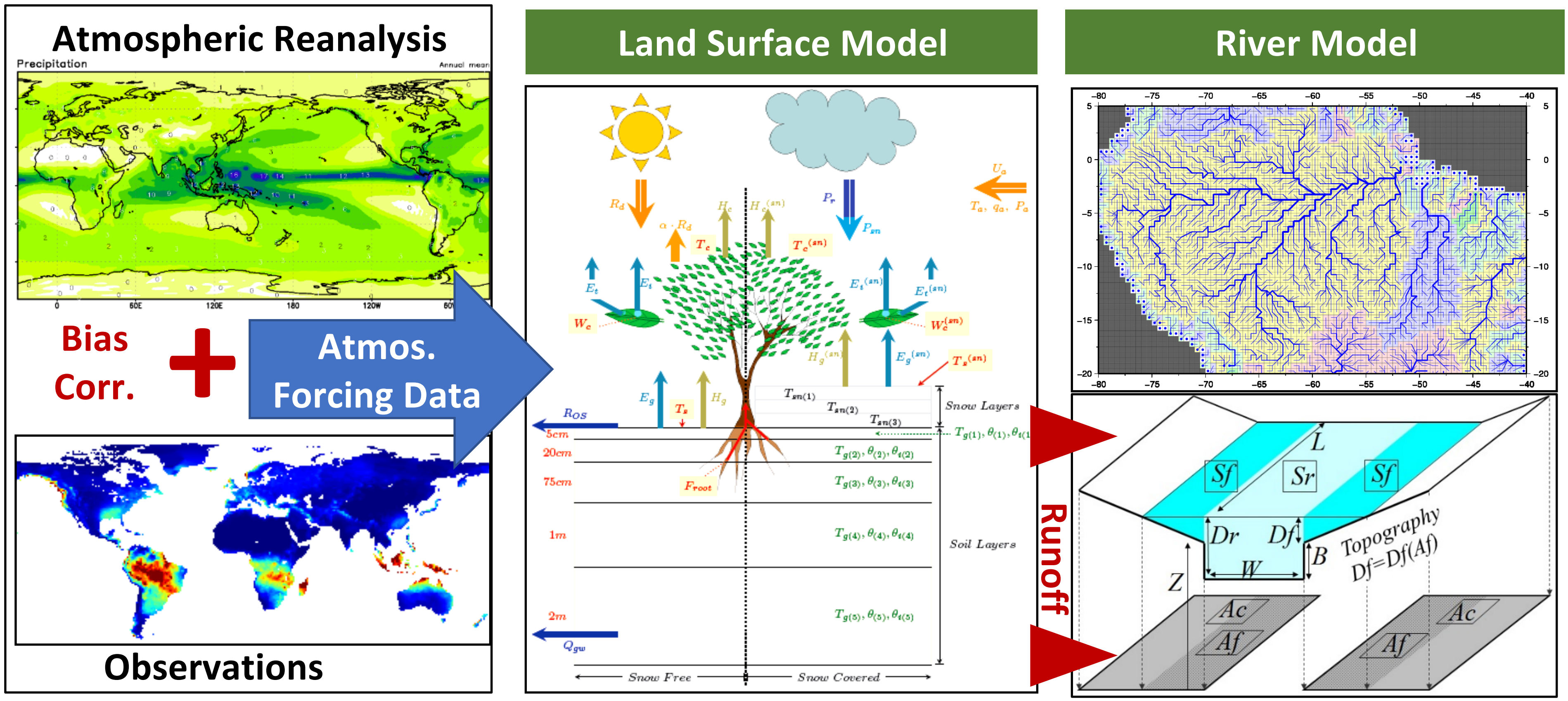
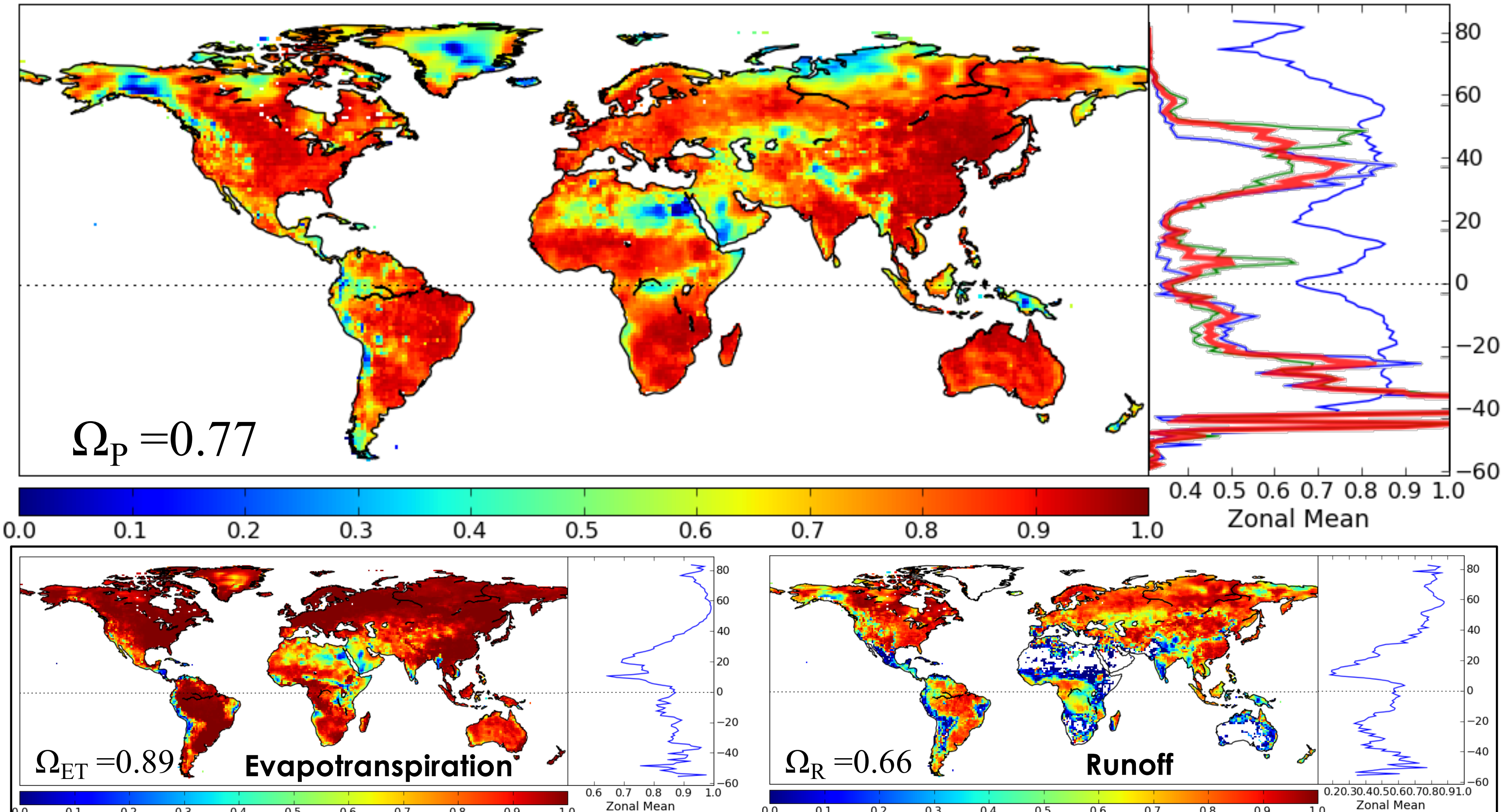
Image courtesy of http://www.satnavi.jaxa.jp/gpmdpr_special/

Off-line Framework for Large-scale Land Simulation



Evaluation / Benchmarking System for
Model Simulations and Input Data

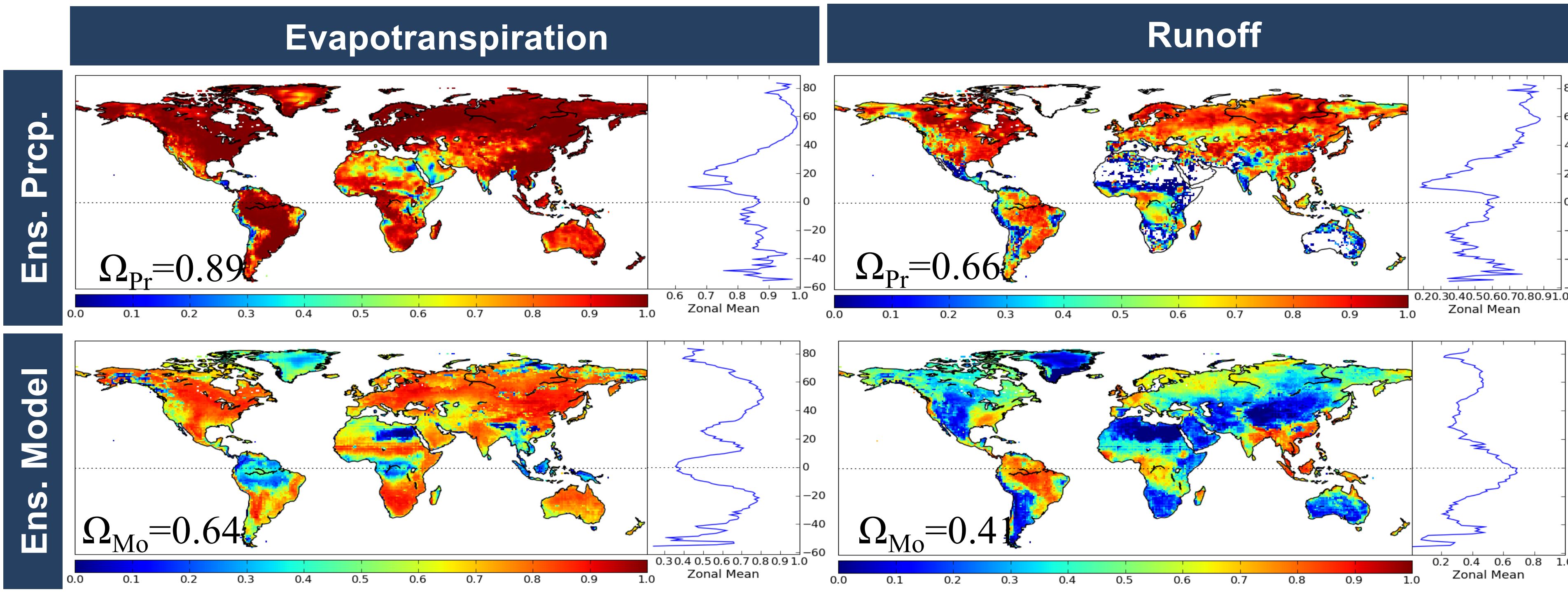
Uncertainty of Simulations



+ Uncertainty in precipitation has heterogeneous global distribution
+ Non-linear impacts in land surface simulations

Kim, 2010

Uncertainty of Precipitation and Model Structure



Uncertainty in simulated evapotranspiration and runoff introduced by **different land surface schemes** in GSWP2 are **larger than** **precipitation uncertainty-induced** uncertainty by 28% and 40% in the similarity index (Ω) globally.

Precipitation uncertainties propagation have similar zonal profile, but uncertainties induced by model physics shows different patterns.

Science Question

Precipitation Measurement Mission for Improved Forcing in Hyper-Resolution Land Surface Models

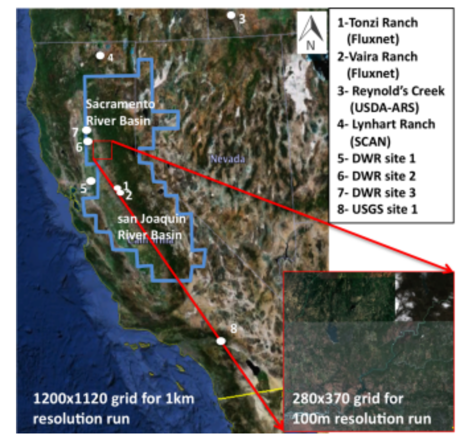
James Famiglietti (PI), Hyungjun Kim (co-PI), and John Reager (co-I)

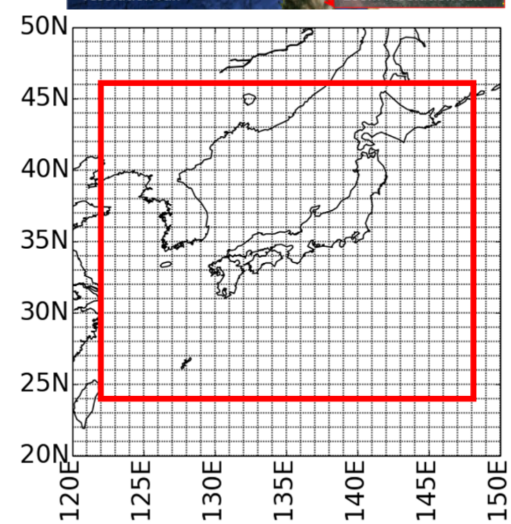
How GPM mission can contribute to hyper-resolution land simulations?

California and Japan as the test-bed because:
1) GPM now covers these regions fully, where TRMM provided limited coverage

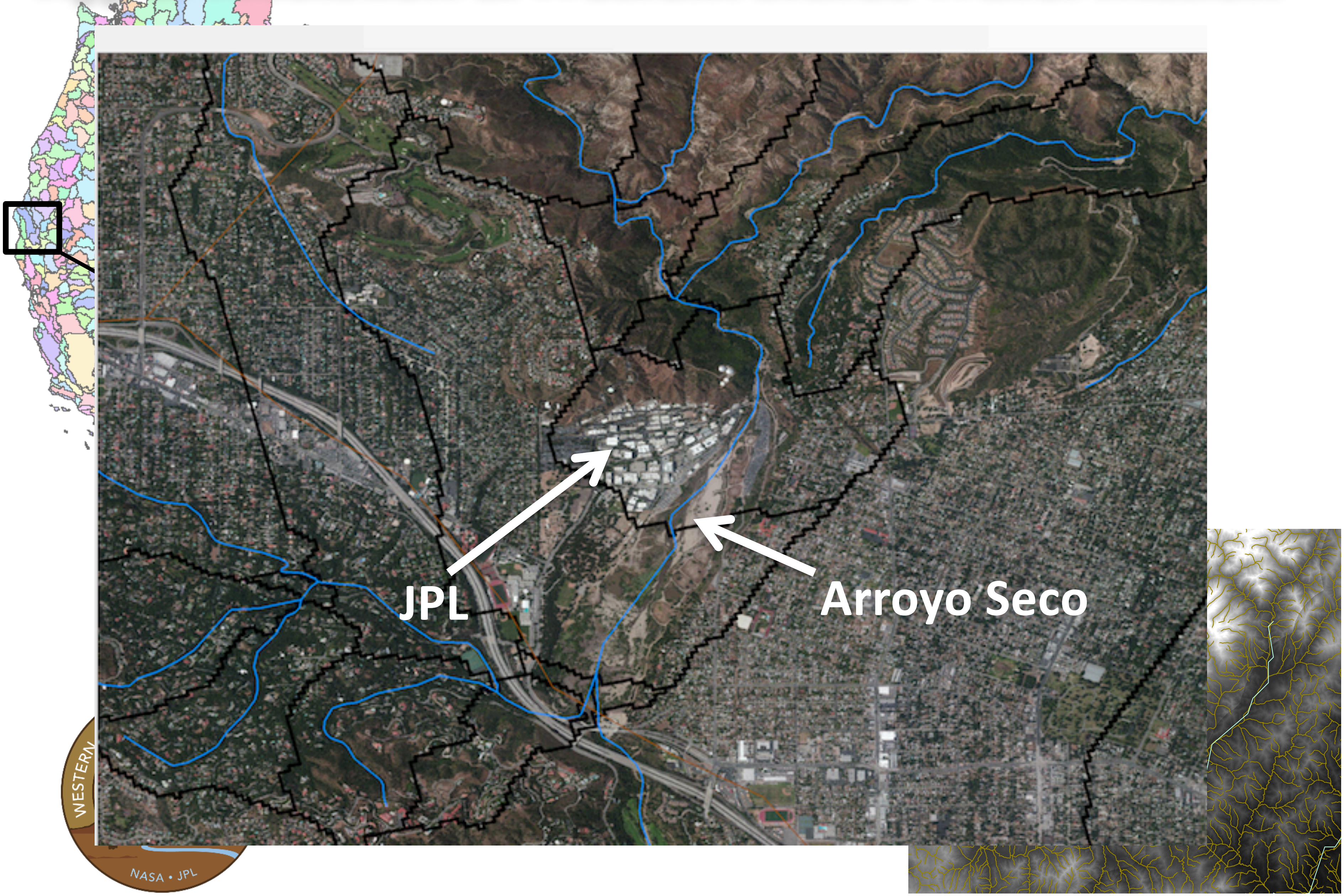
2) Various types of precipitation mechanisms exist in these domains (e.g., typhoon, monsoon, atmospheric rivers, and snowfall)

3) A large range of auxiliary datasets are available for use in validation of precipitation products and model outputs.

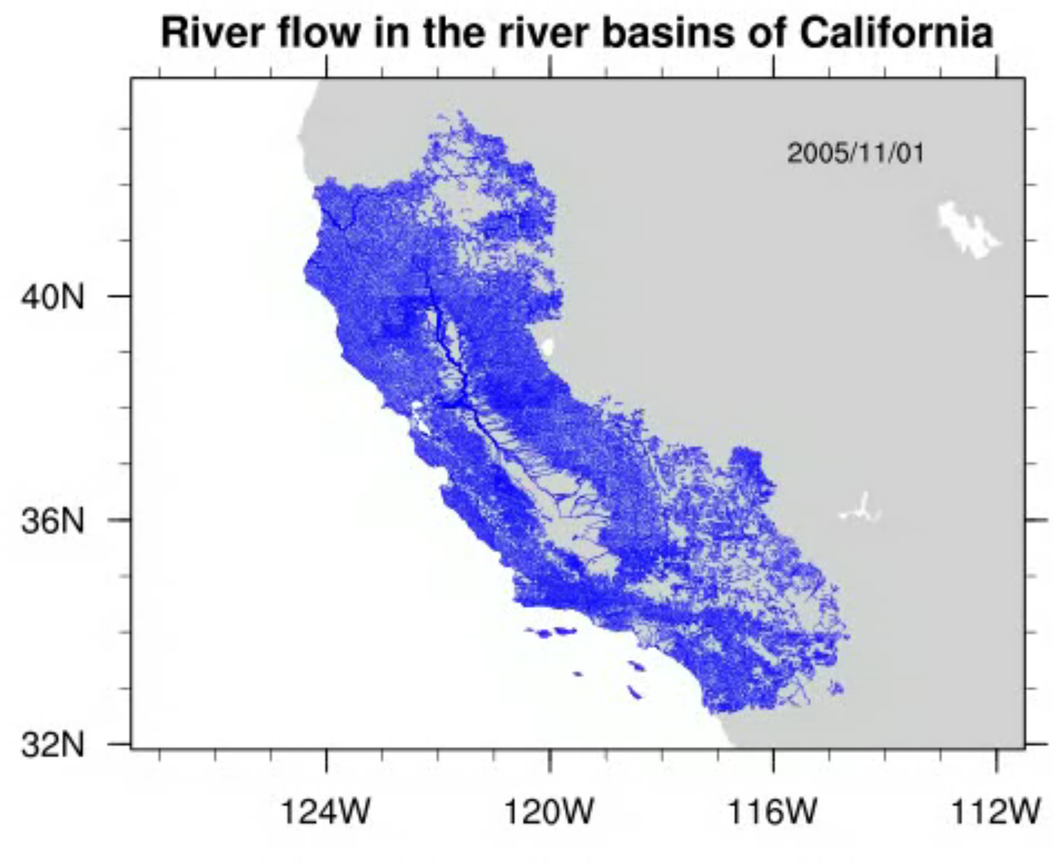




Hyper-resolution & Western States Water Mission



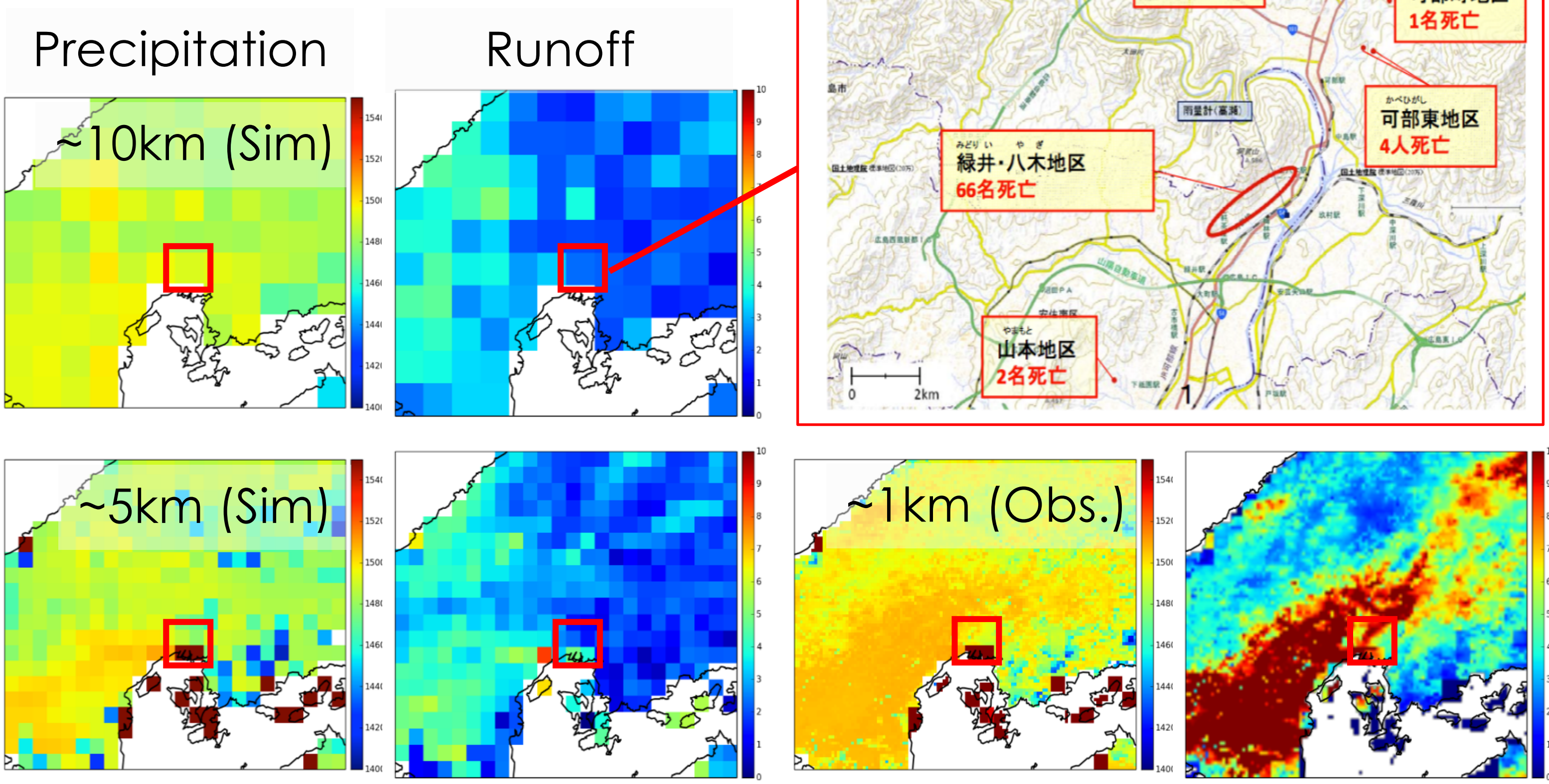
Hyper-resolution & Western States Water Mission



Cedric David, NASA Jet Propulsion Laboratory
David et al., 2015

Hyper-resolution Land Simulations

Landslide @ Hiroshima 2014.08



Yabu et al., in prep.

It has been shown that increased model grid resolution (~1-km) can yield improvement in the estimation of model water balance, especially for state variables that depend heavily on subgrid parameterizations, such as snow water equivalent and runoff generation.

Objectives

Build a test-bed for application of dynamical downscaling technique for hyper-resolution land simulations and investigate the effect of improved meteorological forcing on simulation performance.

High resolution forcing data generation

Develop the methodology to blend dynamically downscaled reanalysis datasets and satellite-based precipitation estimates.

High resolution model simulations

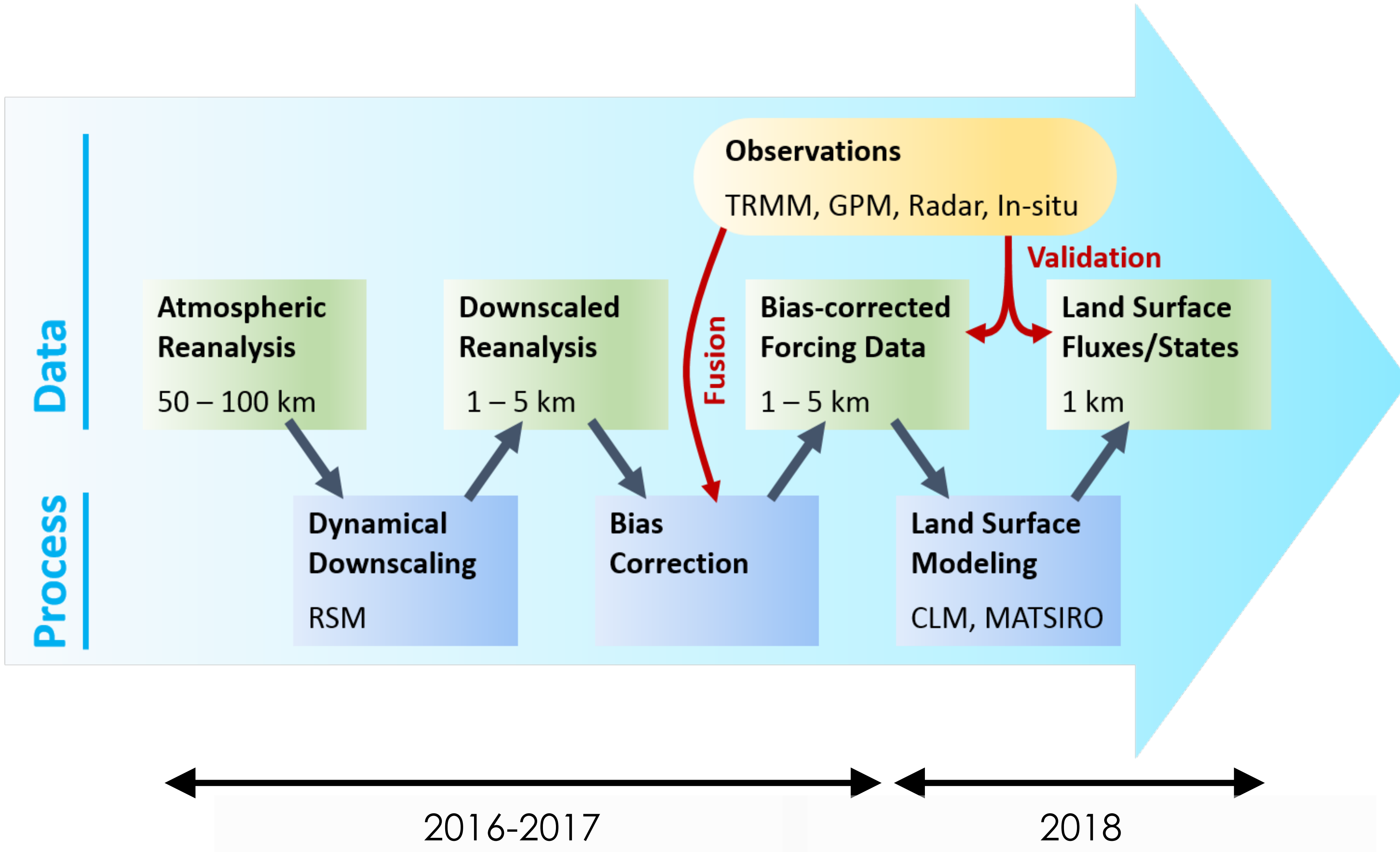
Force the 1-km resolution version of LSMs over the Southwestern US and the Northeast Asia domain with a suite of precipitation at different resolutions.

Analysis: how does precipitation quality/resolution affect hydrology simulations?

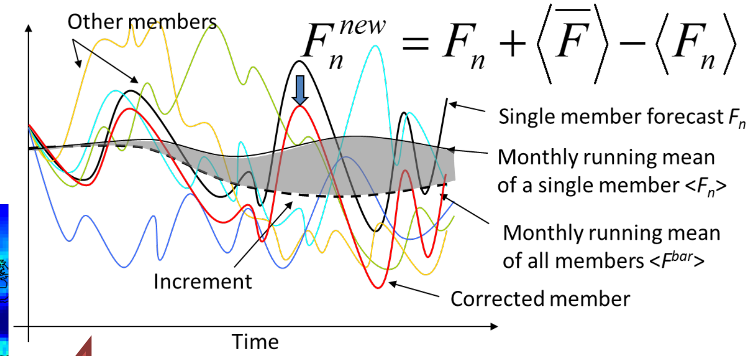
Quantify how the improvement of spatial resolution of precipitation forcing affects the hyper-resolution hydrological simulations.

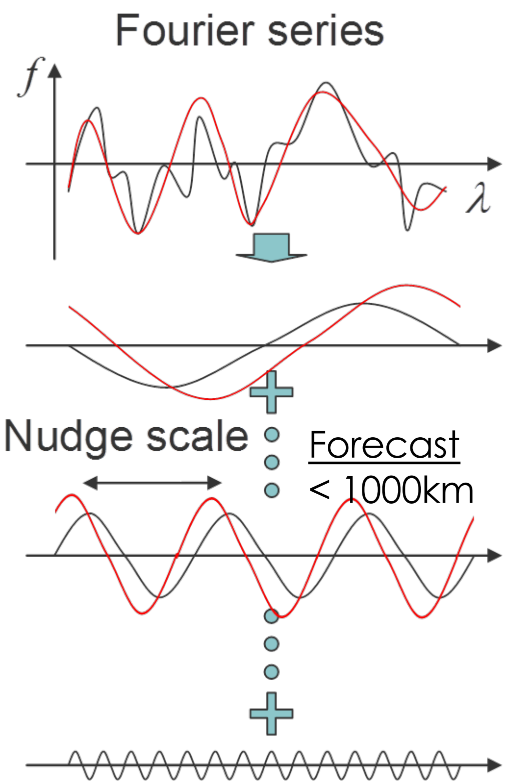
Quantify how the incorporation of satellite-based precipitation product into the precipitation forcing (i.e. the bias correction) affects the hyper-resolution hydrological simulations.

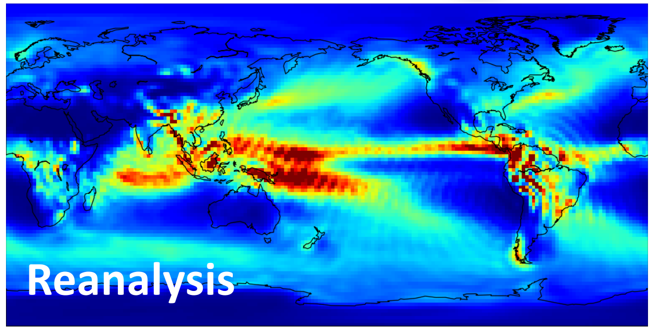
Work Flow & Plan



Spectral Nudging for Global Dynamical Downscaling







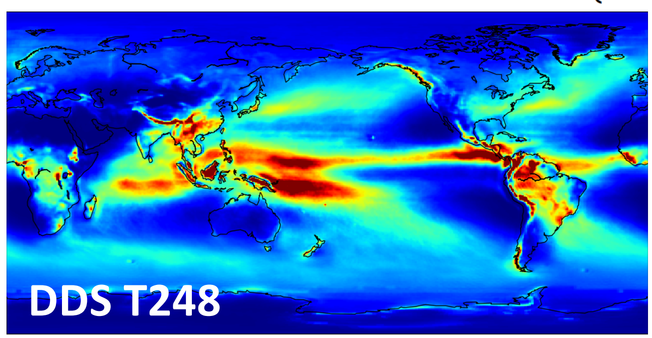
Incremental Correction of Single Member

Yoshimura and Kanamitsu 2013

Nudging U, V, T, P

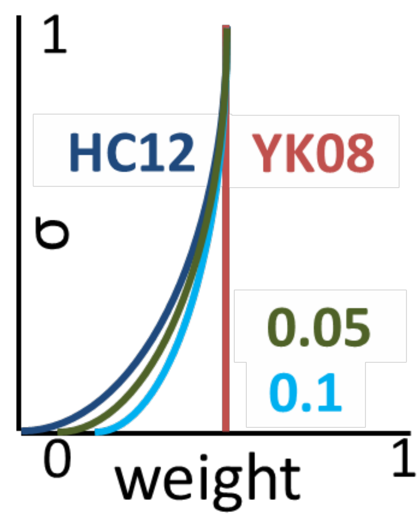
$$f_{(\lambda,\phi)} = \sum_{m=-M}^{m=M} A_{(m,\phi)} e^{im\lambda}, \quad \text{with}$$

$$A_{(m,\phi)} = \begin{cases} A_{f(m,\phi)} & \left(|m| > \dfrac{2\pi R_E \cos\phi}{L}\right) \\ \dfrac{1}{\alpha+1}[A_{f(m,\phi)} + \alpha A_{a(m,\phi)}] & \left(|m| \le \dfrac{2\pi R_E \cos\phi}{L}\right) \end{cases}$$



Yoshimura and Kanamitsu 2008

Vertically Weighted Damping Coef.

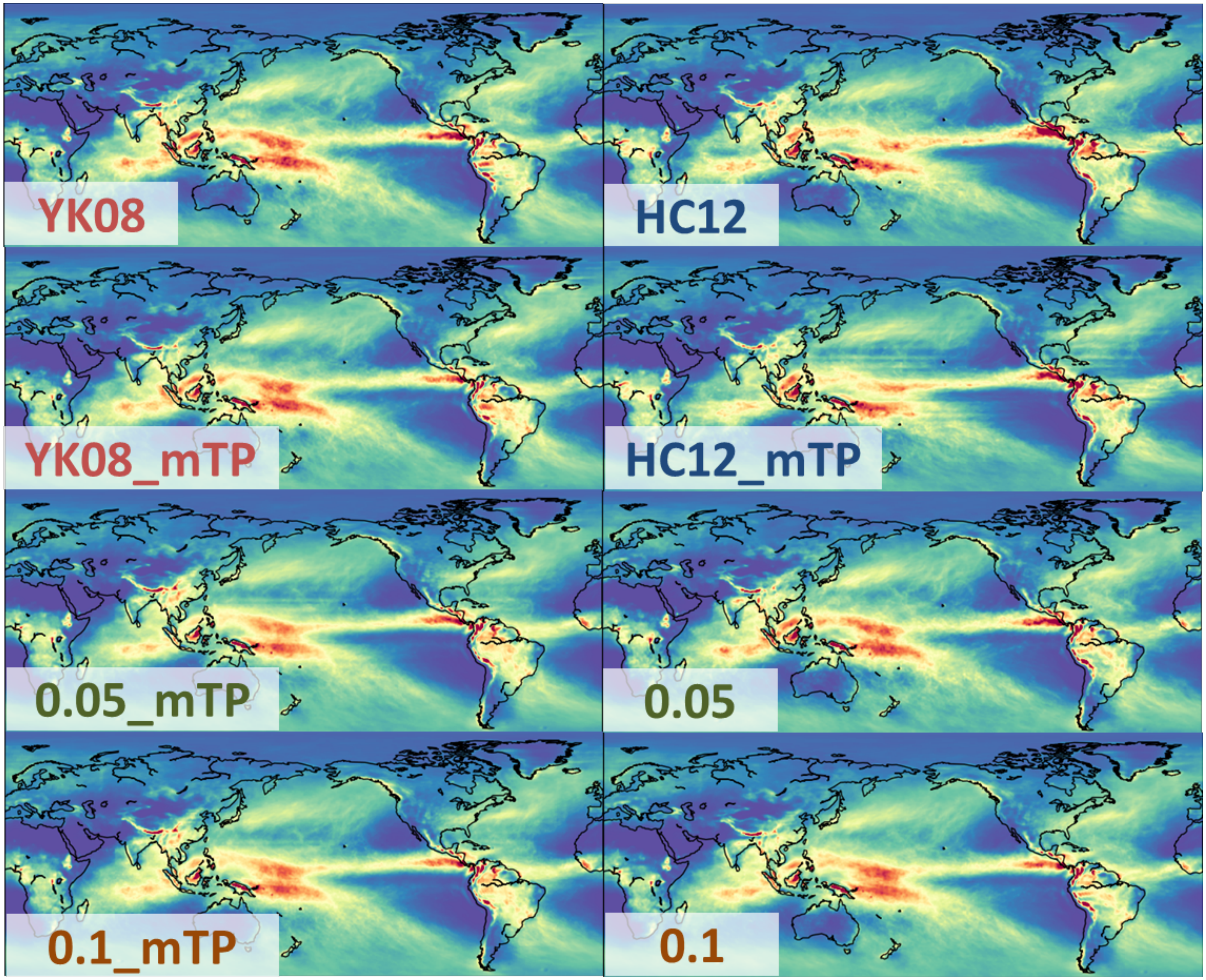


Hong and Chang 2012

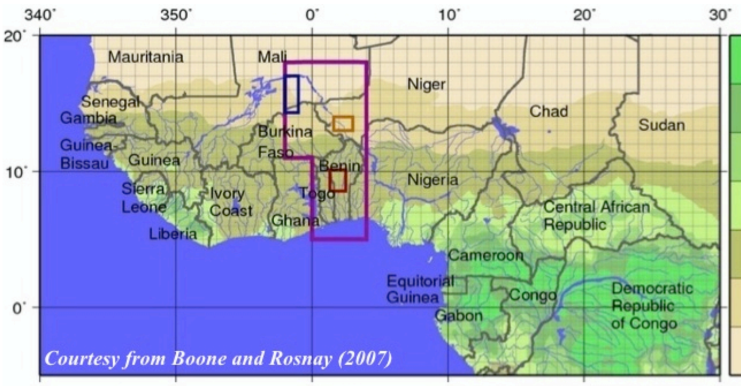
Successfully generate high frequency signals preserving low frequency background.

Effectively relieves ripple-like pattern (an artifact of 20CR due to high-res. topography mismatch)

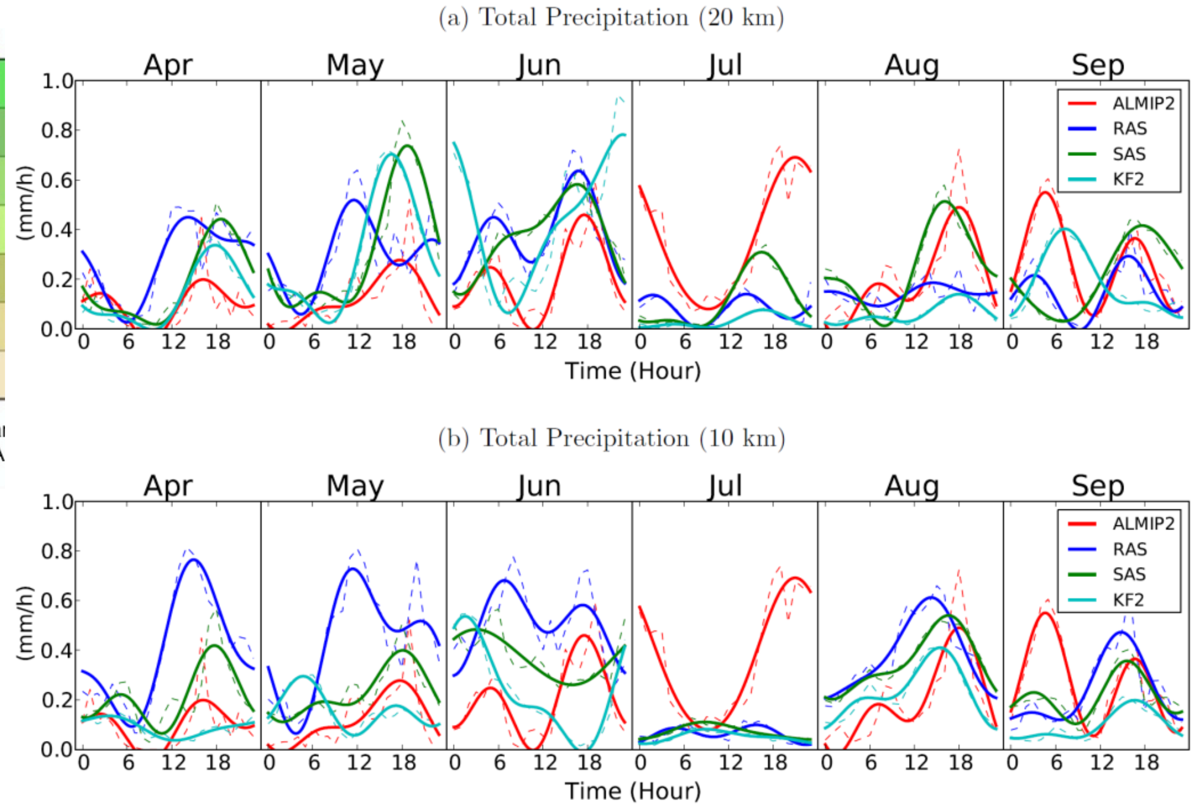
Sensitivity Tests for Damping Weight Profiles



Diurnal Cycle over African Monsoon Region

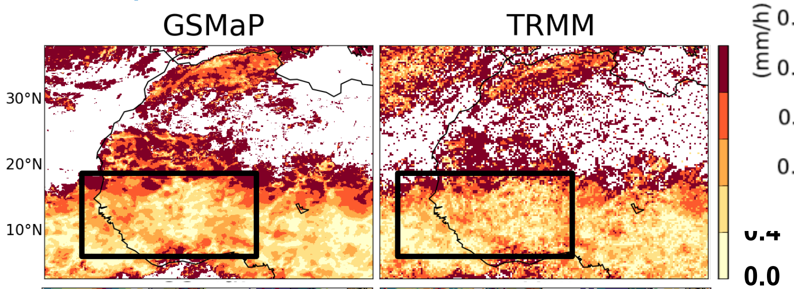


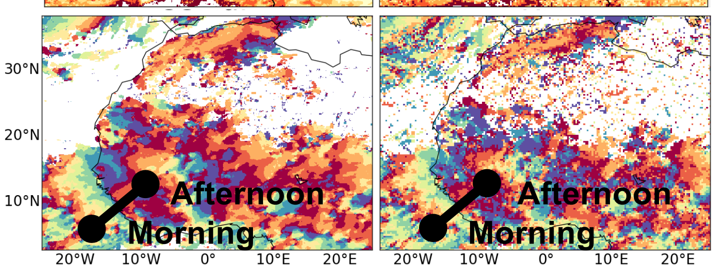
Location of three meso-scale sites: Oueme-Benin (red), South-West Niger (orai and Gourma-Mali (blue). Contours correspond to the annually-averaged Leaf A Index (LAI $m^2 m^{-2}$)

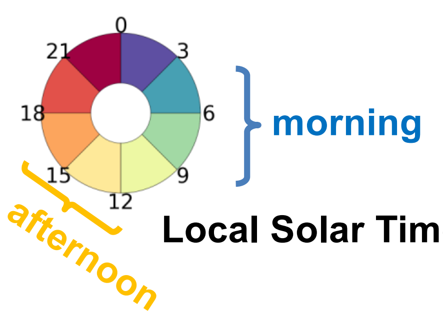


Time (Hour)

Amplitude







Local Solar Time

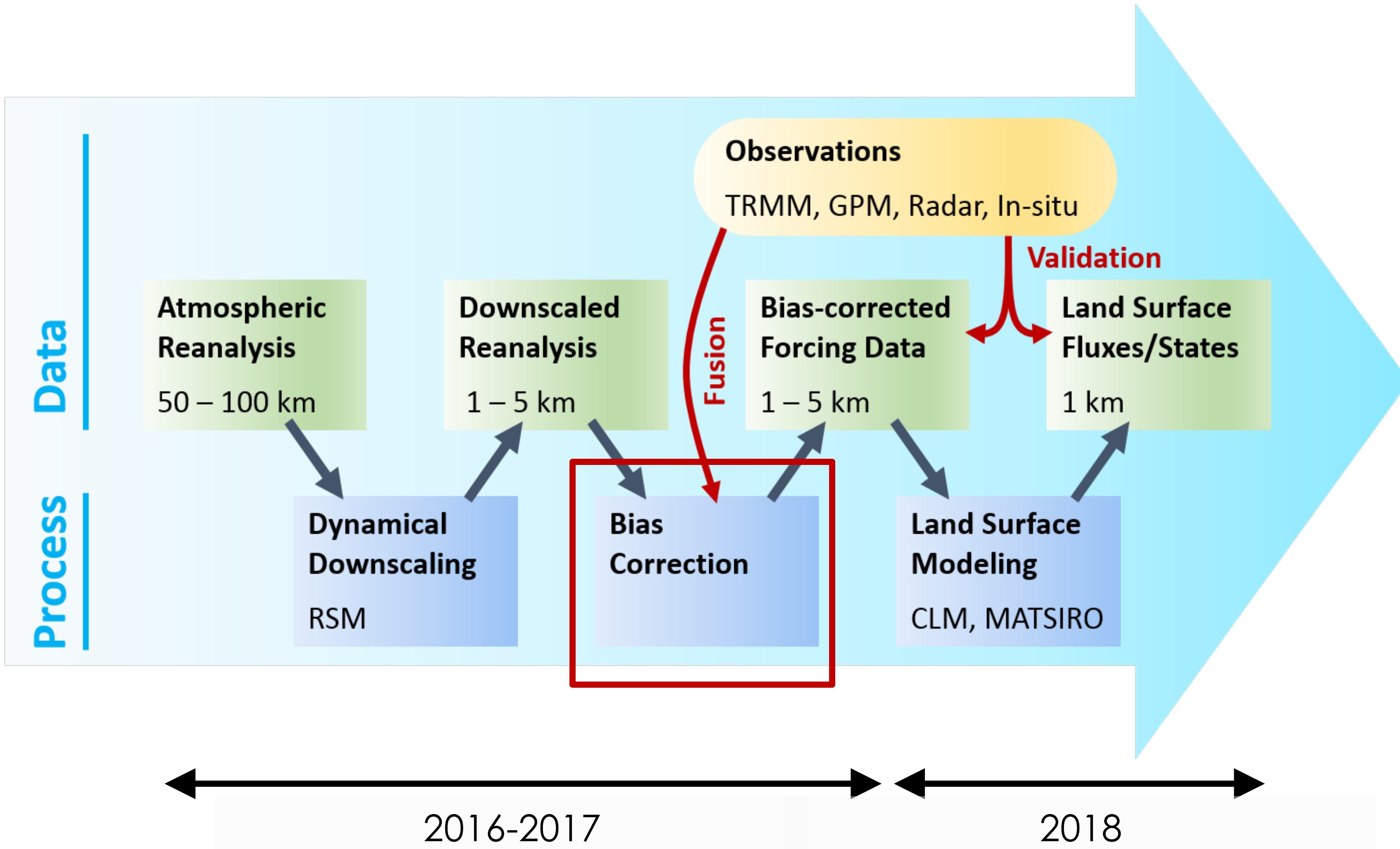
Phase

land (afternoon)

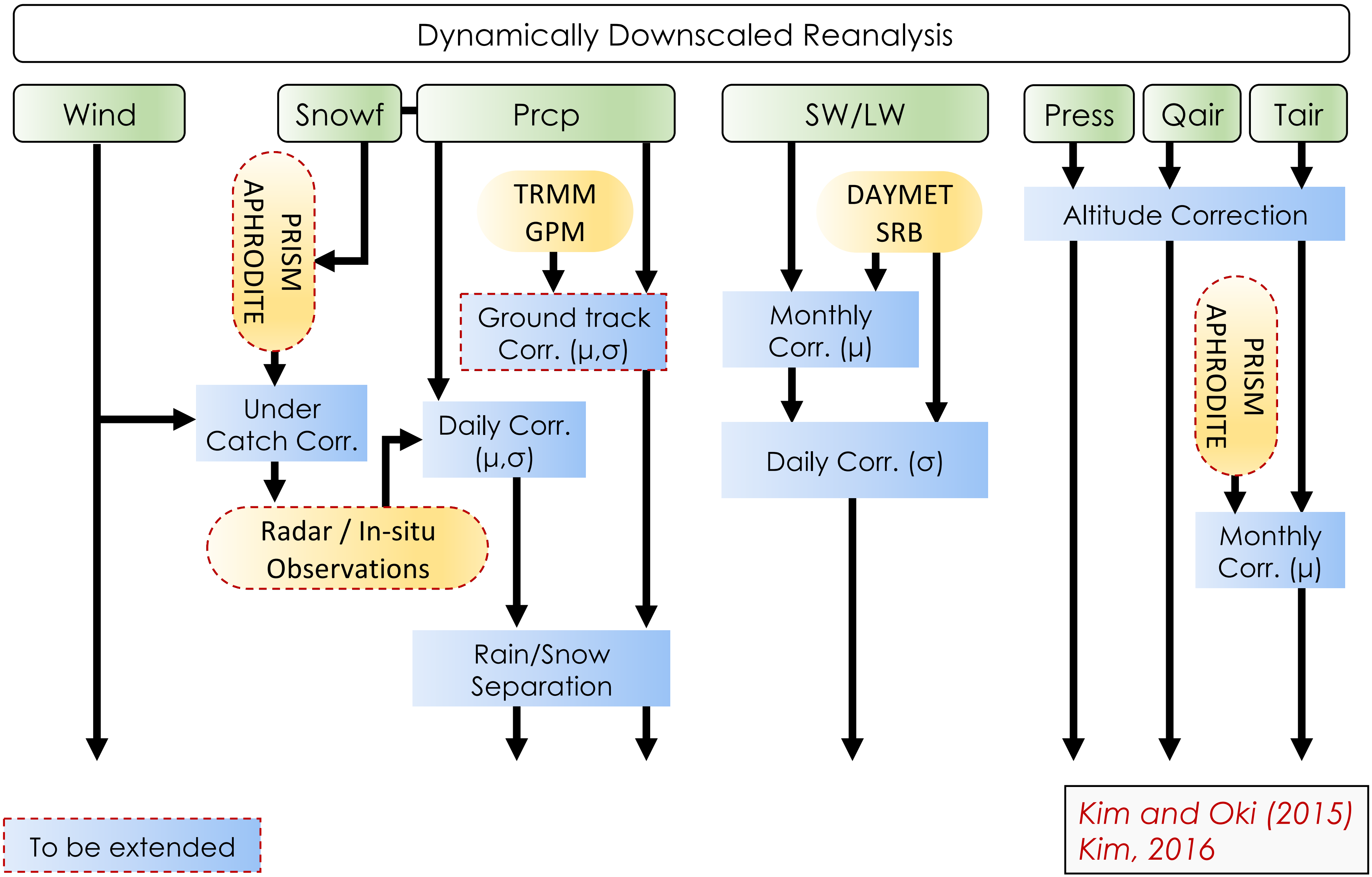
ocean (morning)

** He et al., (2015) The Diurnal Cycle of Precipitation in Regional Spectral Model Simulations over West Africa: Sensitivities to Resolution and Cumulus Schemes. Wea. Forecasting, 30, 424–445.*

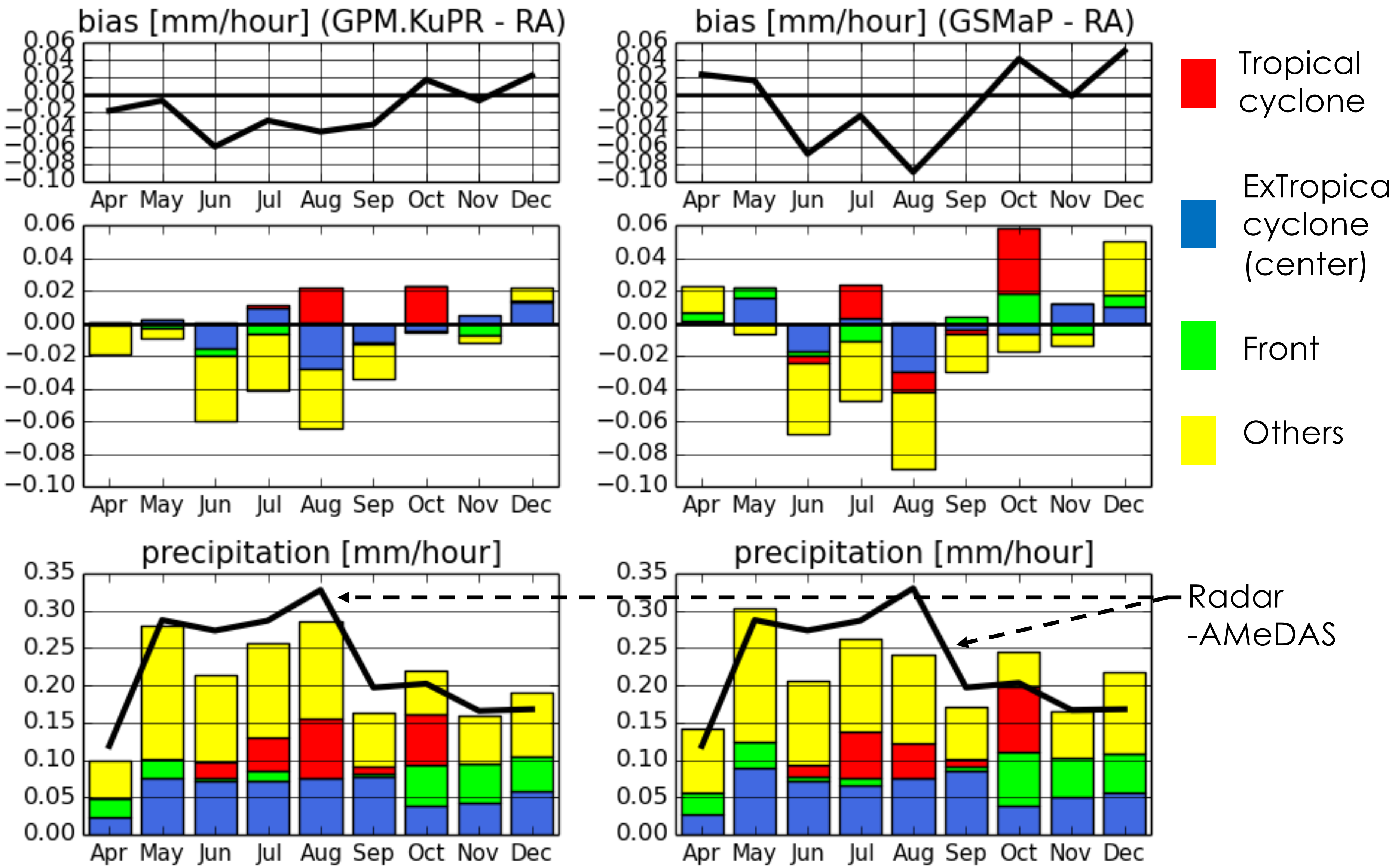
Work Flow & Plan



Bias-correction



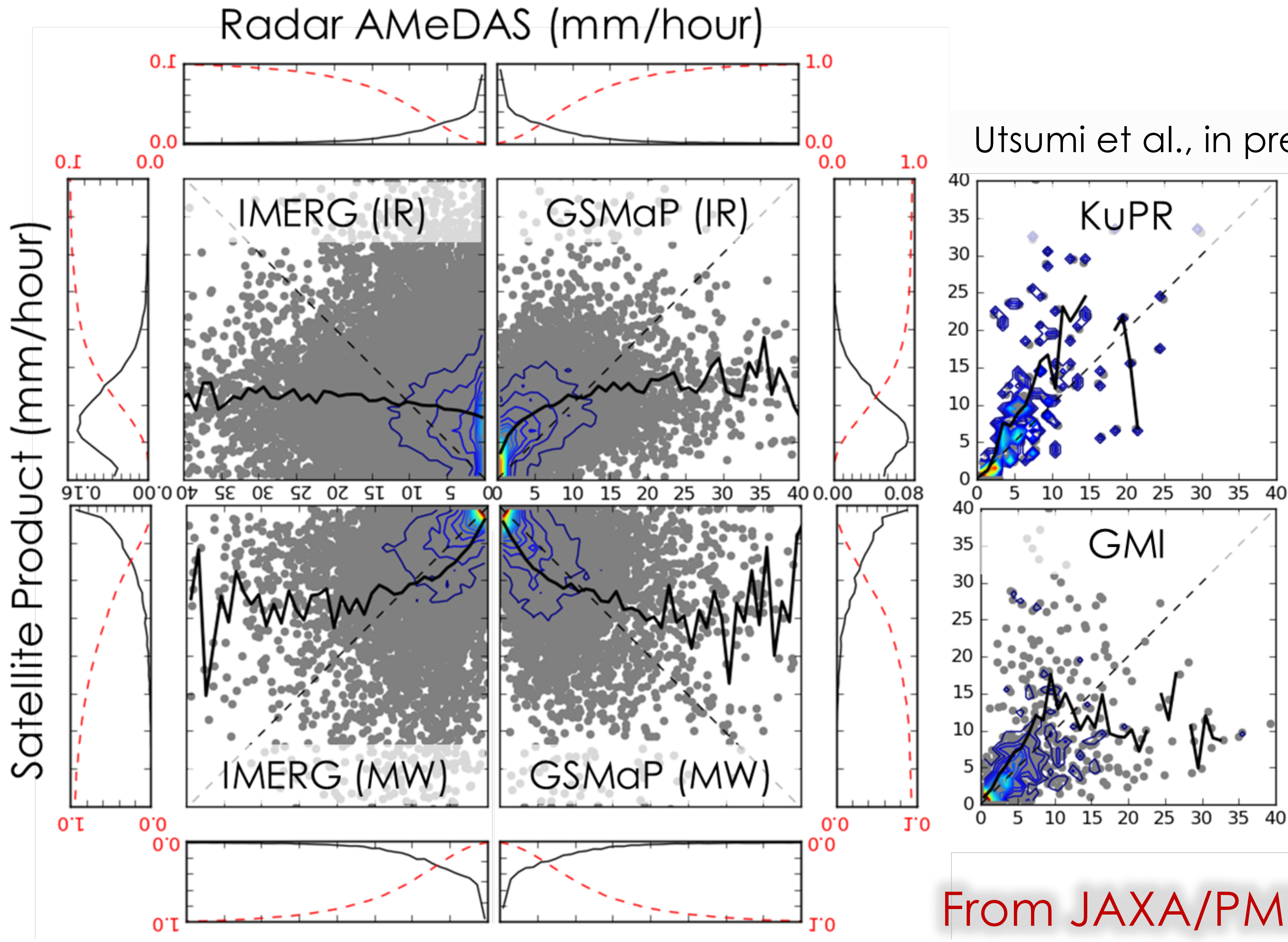
Error Estimation by Weather Systems: Sensitivity



Azariah et al., in prep. / Utsumi et al., in prep.

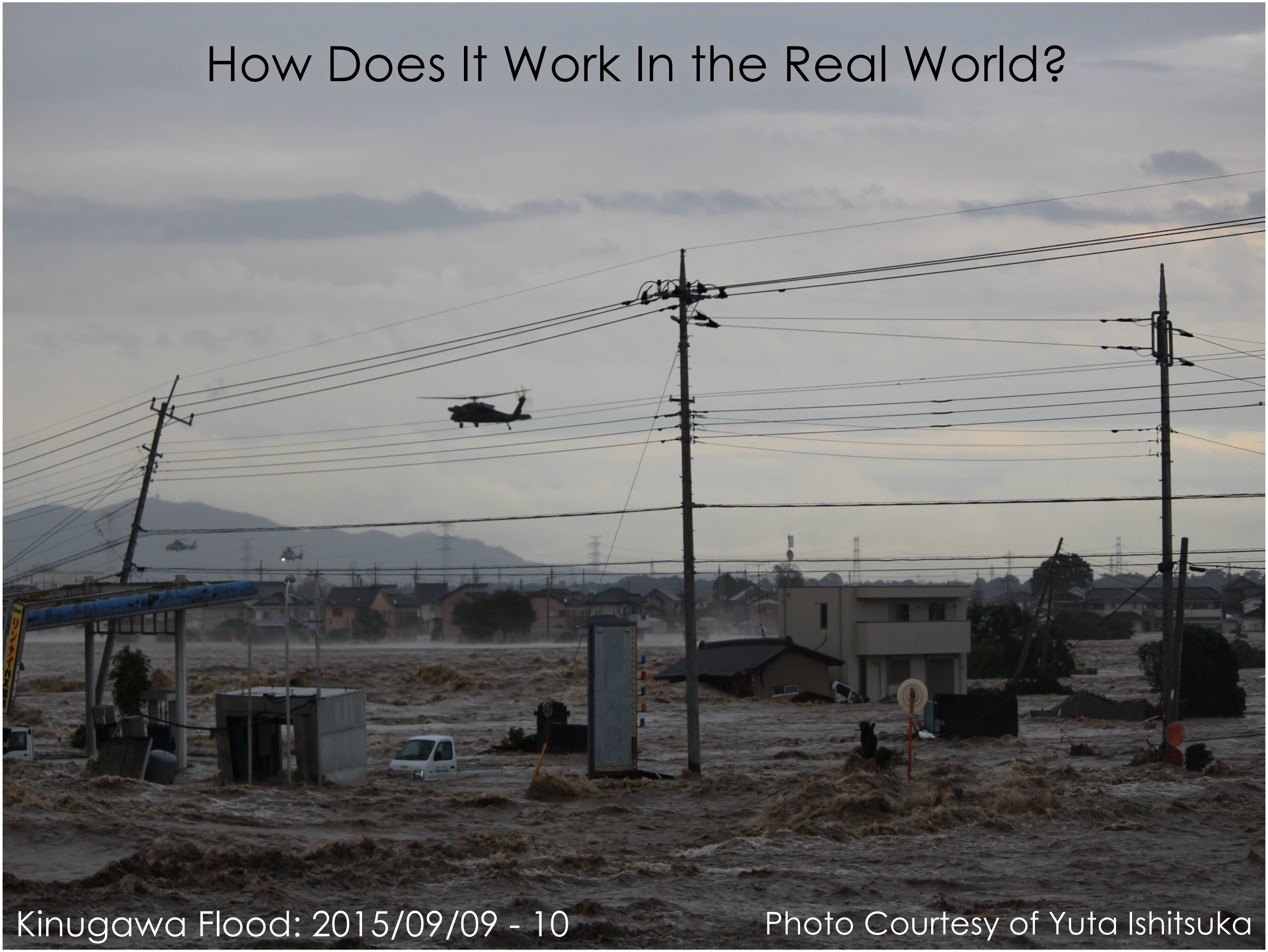
From JAXA/PMM 7th

Retrieval Sensitivity by Cloud Types /* Cumulonimbus */



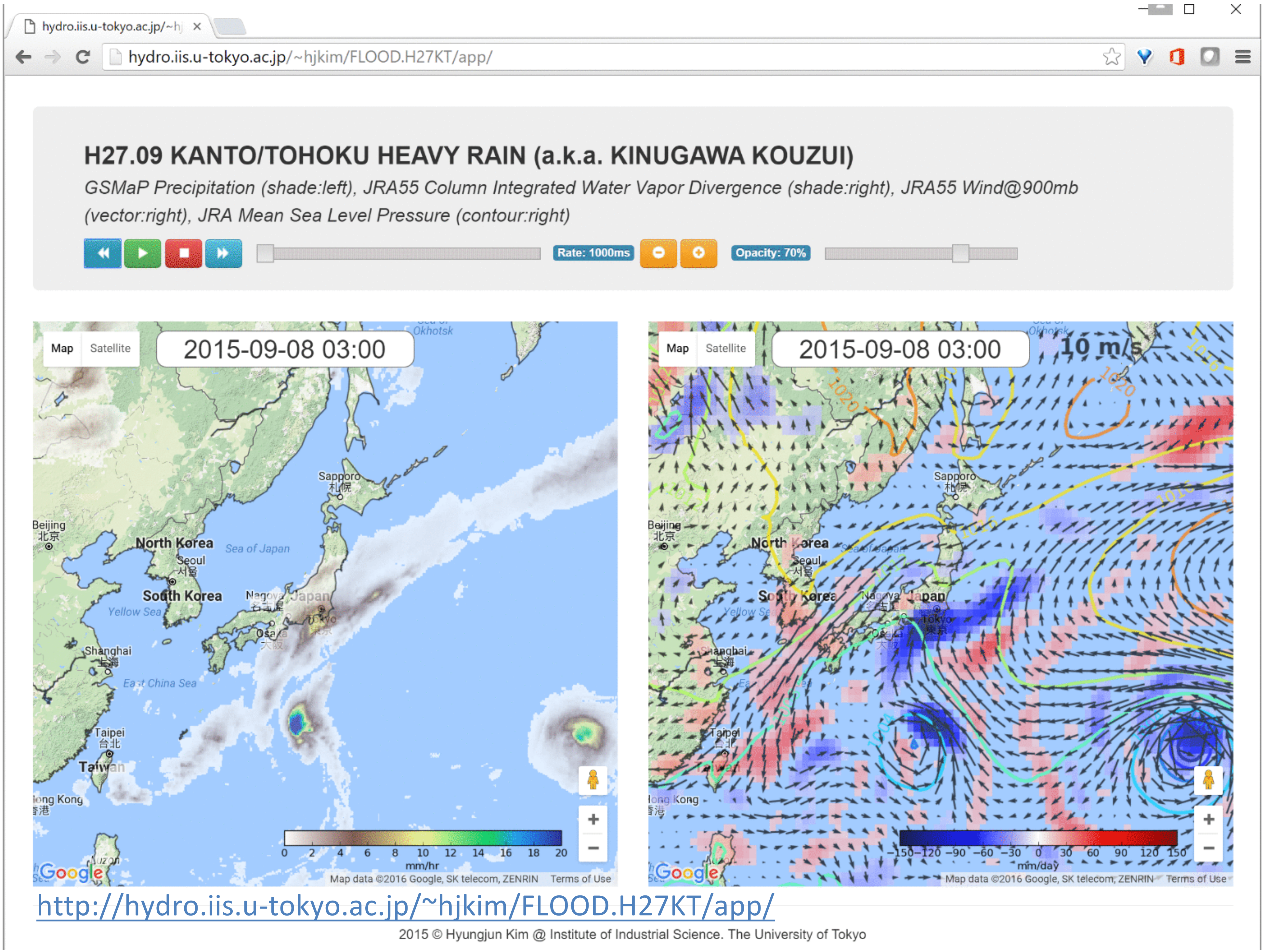
From JAXA/PMM 8th

How Does It Work In the Real World?



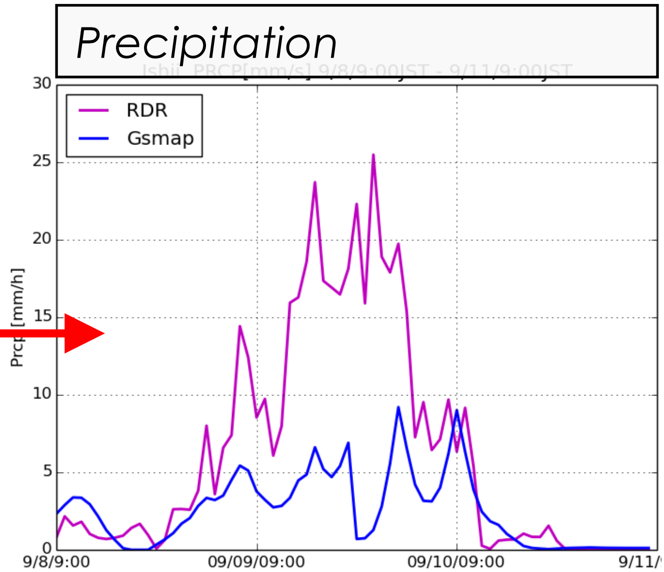
Kinugawa Flood: 2015/09/09 - 10

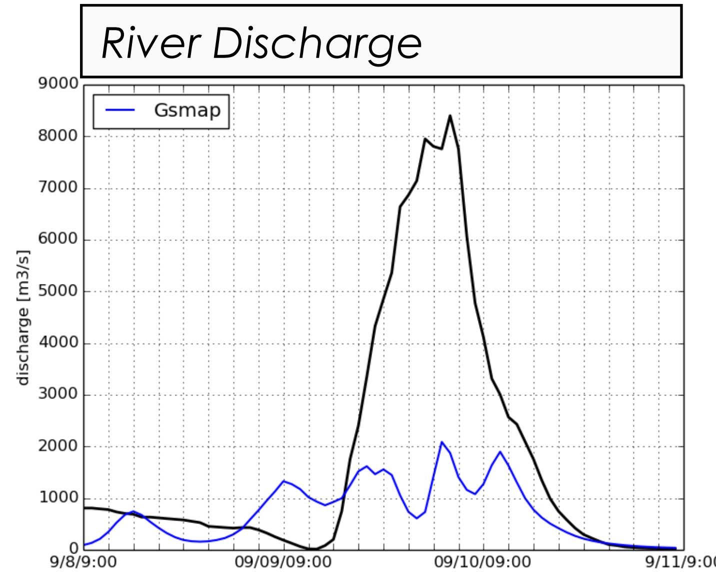
Photo Courtesy of Yuta Ishitsuka

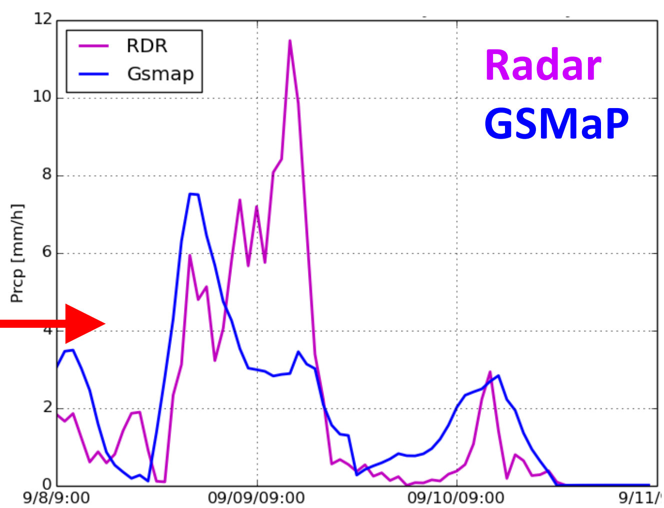


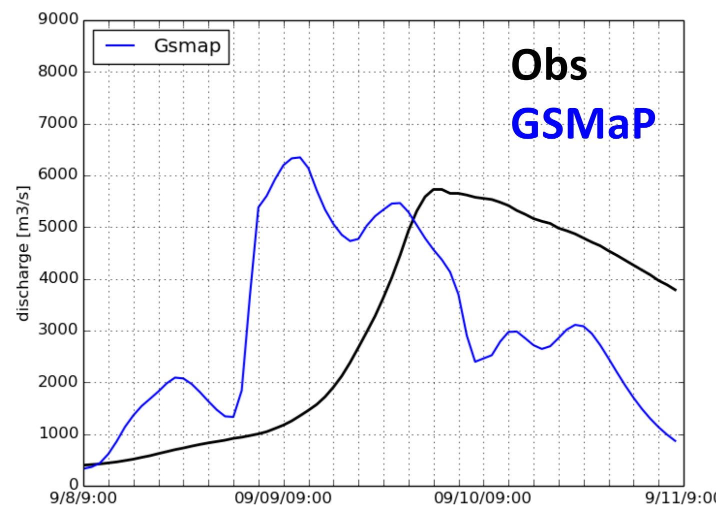
http://hydro.iis.u-tokyo.ac.jp/~hjkim/FLOOD.H27KT/app/

Comparison between Satellite and Ground Radar



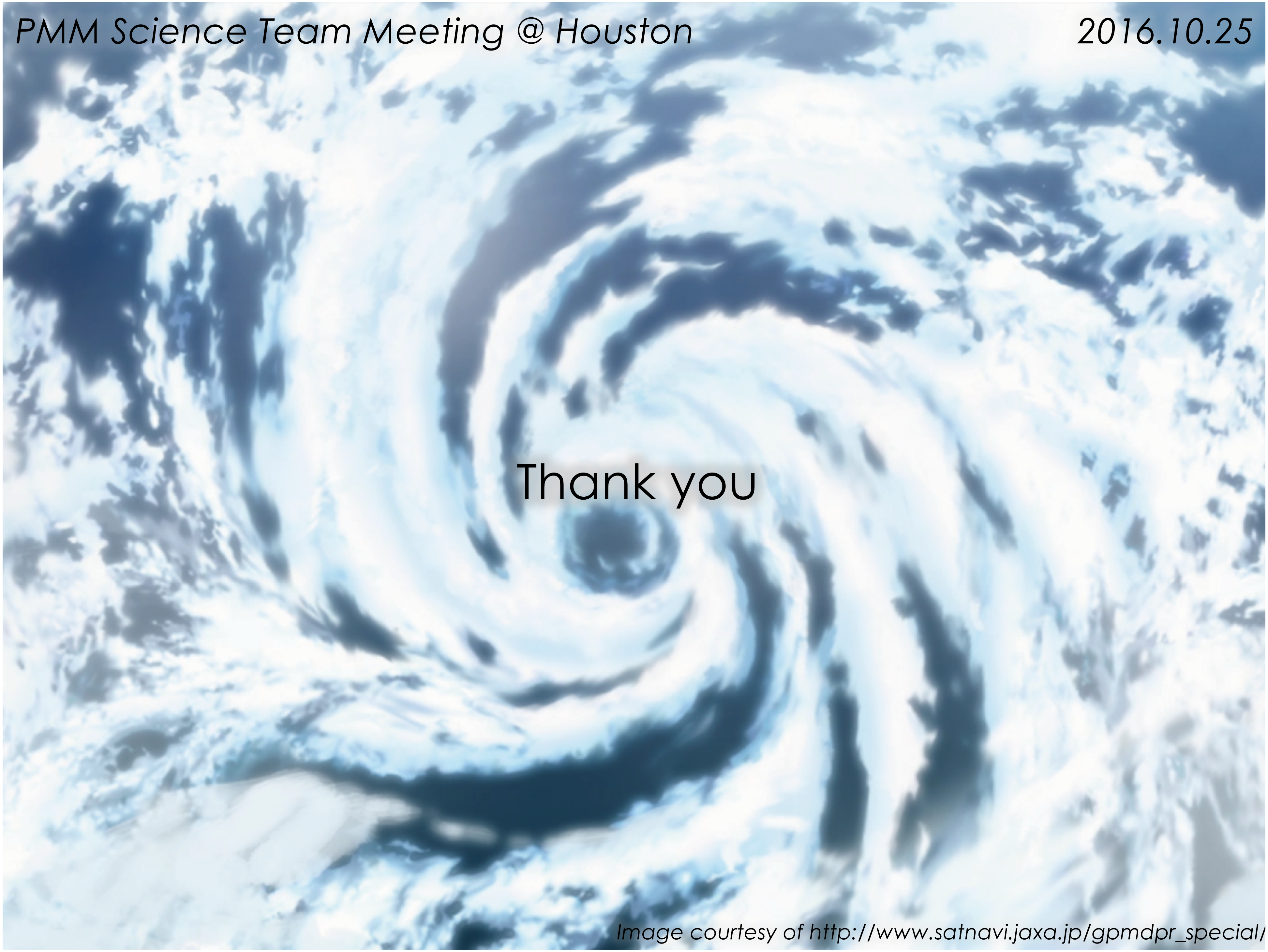






Images Courtesy of http://www.ktr.mlit.go.jp/shimodate/shimodate_know010.html

Ishitsuka et al., in prep.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Thank you
Image courtesy of http://www.satnavi.jaxa.jp/gpmdpr_special/